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REPORT ON WIND TUNNEL TEST OF U.S.A-27-C MODIFIED AIRFOIL

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REPORT ON WIND TUNNEL TEST OF U. S. A.-27-C MODIFIED AIRFOIL.

OBJECT OF TEST AND DESCRIPTION OF THE MODEL.

This airfoil was tested at M. I. T. during September, 1921, to determine lift, drag, L/D , and moments about the leading edge. The test was run at a wind velocity of 30 miles per hour. The area of the model is 68 square inches, and is tapered both in chord and section except for a constant center section extending over 23.4 per cent of the span. The dimensions are: Span 18 inches; chord at center line 4.368 inches.

RESULTS.

The results of the test on this airfoil are compared with results of tests on the original U. S. A.-27-C, the U. S. A.-27, and the Dayton-Wright Gottingen No. 387.

It should be noted in the results on the modified U. S. A.-27-C that the angle of attack is referred to the flat portion of the chord near the trailing edge, and not to the line connecting the leading and trailing edges. This accounts for the rather abnormal angle of zero lift.

The maximum lift coefficient for the modified U. S. A.-27-C is 0.00366 as compared to 0.00332 for the U. S. A.-27-C, 0.00363 for the U. S. A.-27, and 0.00415 for the Dayton-Wright Gottingen No. 387. The minimum drag coefficient is 0.000062, and the ratio of the maximum lift to minimum drag is therefore 59.0. This ratio for the U. S. A.-27-C is 55.3, for the U. S. A.-27 is 45.4, and for the D. W. Gottingen No. 387 it is 42.4. The maximum L/D ratio is 14.1, as compared to 15.2 for the U. S. A.-27-C, 16.0 for the U. S. A.-27, and 13.5 for the D. W. Gottingen No. 387.

The high speed for pursuit airplanes is compared by the L/D taken at $1/9$ maximum K_y . The L/D for the modified model of the U. S. A.-27-C at this K_y is 5.65, as compared to 6.1 for the U. S. A.-27-C, 4.6 for the U. S. A.-27, and 4.5 for the D. W. Gottingen No. 387. The high speed for reconnaissance airplanes is compared by the L/D taken at $1/6.25$ of the maximum K_y . At this K_y the L/D for the modified U. S. A.-27-C is 8.7, as compared to 8.8 for the U. S. A.-27-C, 7.0 for the U. S. A.-27, and 6.75 for the D. W. Gottingen No. 387. The high speed for bombers is taken at the angle corresponding to $1/4$ maximum K_y . At this angle the L/D for the modified U. S. A.-27-C is 12.4, while that for the U. S. A.-27-C is 12.6, 11.7 for the U. S. A.-27, and 10.45 for the D. W. Gottingen No. 387.

A comparable value for the speed range is obtained by means of the formula

$$\frac{\sqrt{K_y \text{ maximum}}}{\sqrt[3]{K_x \text{ minimum}}}$$

The value for the modified U. S. A.-27-C is 1.525, for the U. S. A.-27-C it is 1.478, and for both the U. S. A.-27 and the D. W. Gottingen No. 387 it is 1.410.

The ceiling and climb for constant loading is expressed by the maximum value of the formula $K_y^{1/2}/K_x$. The maximum value of this expression for the modified U. S. A.-27-C is 0.578, 0.650 for the U. S. A.-27-C, 0.665

for the U. S. A.-27, and 0.623 for the D. W. Gottingen No. 387. The ceiling and climb for constant landing speed is expressed by the minimum value of the formula

$$\frac{\sqrt{K_y \text{ maximum}}}{K_y \frac{L}{D}}$$

For the modified U. S. A.-27-C the minimum value of the above expression is 0.1046, for the U. S. A.-27-C it is 0.0885, for the U. S. A.-27 it is 0.0908, and for the D. W. Gottingen No. 387 it is 0.1035.

The most forward position of the center of pressure is 33.8 per cent of the chord back of the leading edge for the modified U. S. A.-27-C, 29.6 per cent for the U. S. A.-27-C, 27.4 per cent for the U. S. A.-27, and 32.0 per cent for the D. W. Gottingen No. 387.

The center of pressure travel in per cent of the chord between the most forward position and the position at the angle of $\frac{K_y \text{ maximum}}{6.25}$ for the modified U. S. A.-27-C is

31.0 per cent, for the U. S. A.-27-C it is 32.2 per cent, for the U. S. A.-27 it is 39.6 per cent, and for the D. W. Gottingen No. 387 it is 41.0 per cent.

The modified U. S. A.-27-C is of the thick-wing type section, having sufficient depth for internally braced construction. The spar depths for the various airfoils discussed in this report are given in Table I.

Table II and figures 1 and 2 give the characteristics of the airfoil. Table III is a table of ordinates expressed in per cent of chord. Figure 3 is a three-view drawing of the model.

It is noted that the ratio of the maximum lift to the minimum drag for the modified U. S. A.-27-C is 59.0 per cent, this value being a remarkably high one and higher than the corresponding values for the other sections discussed. The maximum lift coefficient is excellent, it being less than the D. W. Gottingen No. 387, slightly better than the U. S. A.-27, and considerably superior to the U. S. A.-27-C. The maximum L/D ratio is 14.1 per cent, which is less than either the U. S. A.-27 or the U. S. A.-27-C, but greater than the value for the D. W. Gottingen No. 387, which is 13.5 per cent. A comparison of the L/D ratio for high speeds of various types of airplanes show the values for the modified U. S. A.-27-C to be slightly less than the U. S. A.-27-C and considerably superior to either the U. S. A.-27 or the D. W. Gottingen No. 387.

The speed range for the modified U. S. A.-27-C is exceptionally high, being 1.525, which is greater than the value for any of the other sections discussed. On the other hand, the values for ceiling and climb for both constant loading and constant landing speed are very poor, the value for constant loading being 0.578, which is considerably less than the minimum value for any of the other sections, and for constant landing speed the value is 0.1046, which is much higher than the value for any of the other sections. In this latter case the minimum value is the criterion of merit.

The most forward position of the center of pressure for the modified U. S. A.-27-C is 33.8 per cent, while the center of travel is 31.9 per cent of the chord. The most forward position of the center of pressure is a little farther back on the chord than any of the other sections, while the center of pressure travel is not so great as any of the others.

TABLE I.—Comparison of airfoils.

Airfoil.	Dayton-Wright Gottingen 387.	U. S. A.-27.	U. S. A.-27-C.	U. S. A.-27-C (modified).
Ky maximum (landing).....	0.00415	0.00363	0.00332	0.00366
Kx minimum.....	.000098	.00008	.00006	.000062
Ky maximum/Kx minimum.....	42.4	45.4	55.3	59.0
L/D maximum (cruising).....	13.5	16.1	15.2	14.1
High-speed pursuit, L/D at 1/9 Ky maximum.....	4.5	4.6	6.1	5.65
High-speed reconnaissance, L/D at 1/6/25 Ky maximum.....	6.75	7.0	8.8	8.7
High-speed bomber, L/D at 1/4 Ky maximum.....	10.45	11.7	12.6	12.4
Speed range \sqrt{Ky} maximum.....	1.410	1.410	1.478	1.525
\sqrt{Kx} minimum.....				
Ceiling and climb for constant loading $Ky^{3/2}/Kx$ maximum.....	.623	.665	.650	.578
Ceiling and climb for constant landing speed \sqrt{Ky} max. min. L/D1035	.0908	.0885	.1046
Most forward position of center of pressure.....	32.0	27.4	29.6	33.8
Center of pressure travel in per cent of chord between most forward position and position at angle of Ky max./6.25.....	41.0	39.6	39.2	31.0
Spar depths:				
10 per cent from leading edge.....	12.07	9.17	13.23	13.23
15 per cent from leading edge.....	13.83	10.40		
60 per cent from leading edge.....	11.05	9.27	13.33	13.33
70 per cent from leading edge.....	8.62	7.90	11.00	11.00
Authority.....	M. I. T.	M. I. T.	M. I. T.	M. I. T.
Velocity (miles per hour).....	30	30	30	30
Aspect ratio.....		6	6	

TABLE II.

Authority, Aerodynamical Laboratory, M. I. T., September, 1921; velocity, 30 miles per hour; model, 18 by 4.368 inches at centerline, wood.

α .	Ky.	Kx.	L/D.	M_c .	C. P.
-10	-0.00048	0.000138	-3.55	-0.0000414	
-8	-0.00007	.000089	-.74	-.000213	
-6	+.00033	.000070	+4.62	-.000296	0.934
-4	.00070	.000062	10.24	-.000403	.588
-2	.00107	.000079	13.60	-.000513	.476
0	.00148	.000105	14.05	-.000631	.427
+2	.00181	.000137	13.23	-.000730	.400
+4	.00216	.000174	12.42	-.000834	.382
6	.00250	.000219	11.40	-.000932	.371
8	.00284	.000267	10.65	-.00103	.359
10	.00318	.000329	9.68	-.00114	.355
12	.00343	.000384	8.95	-.00121	.350
14	.00366	.000447	8.18	-.00123	.334
16	.00214	.000679	3.16	-.000902	.357
20	.00201	.000887	2.27	-.000923	.414

TABLE III.

MODIFIED U. S. A.-27-C.

(Ordinates expressed in per cent of chord.)

Per cent chord.	Ordinates.	
	Upper.	Lower.
0.00	2.35	2.35
2.50	8.475	-.175
5.00	8.900	-.375
10.00	12.000	-1.235
20.00	14.775	-2.125
30.00	15.537	-2.150
40.00	15.125	-1.800
50.00	14.000	-1.233
60.00	12.400	-.925
70.00	10.500	-.500
80.00	8.125	-.100
100.00	.875	+.875

Radius leading edge=1.06.
Radius trailing edge=0.21.

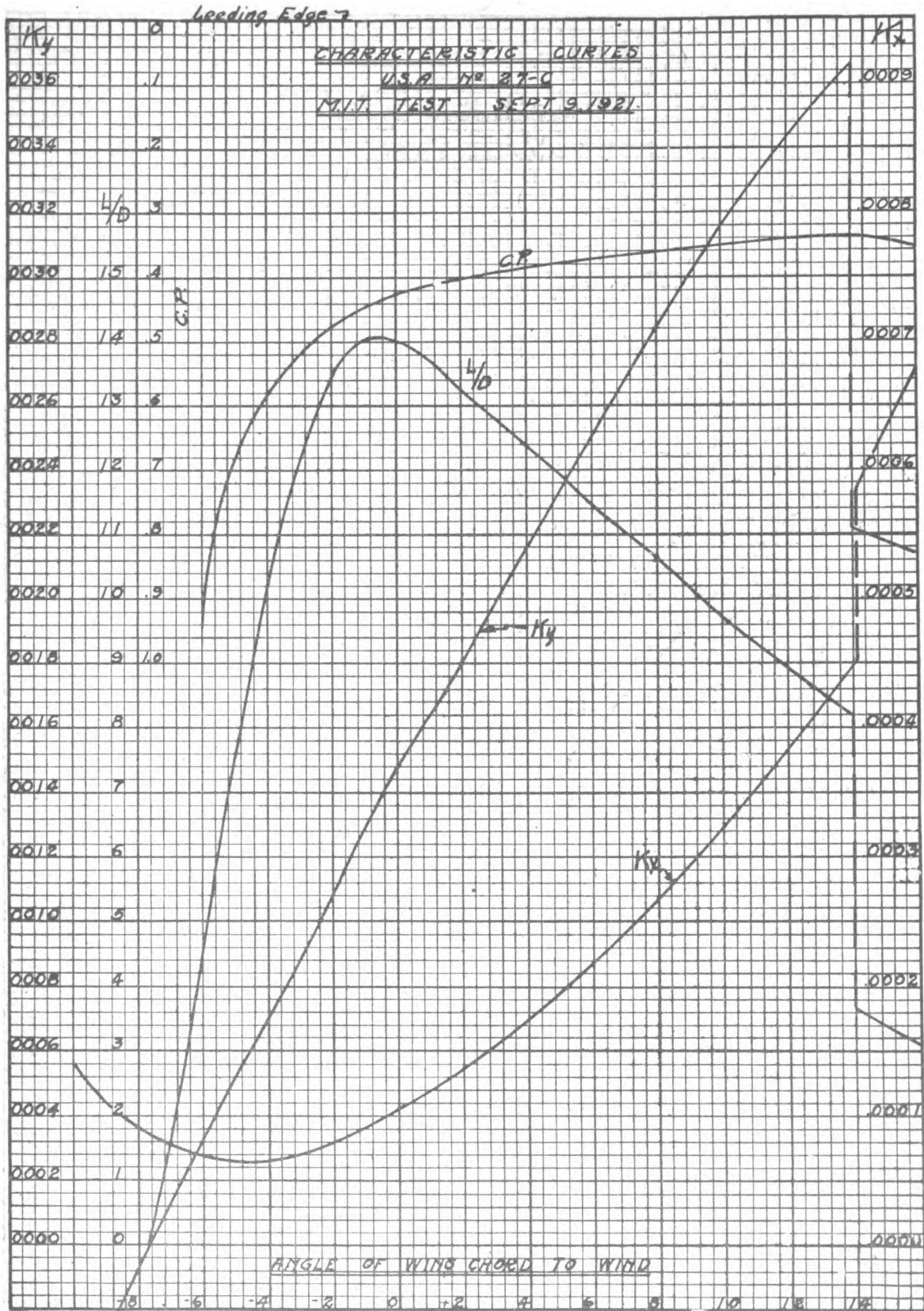


FIG. 1.

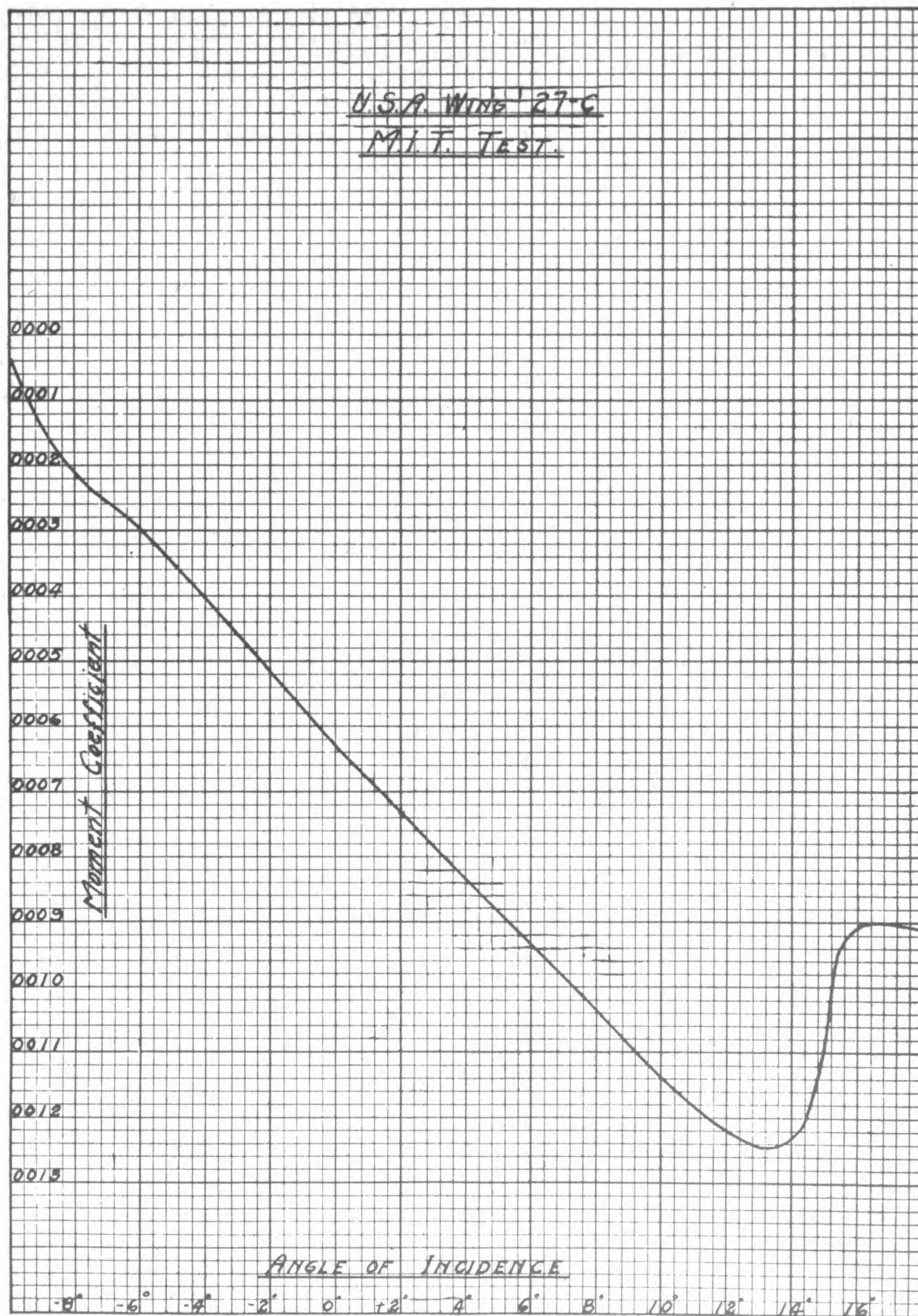
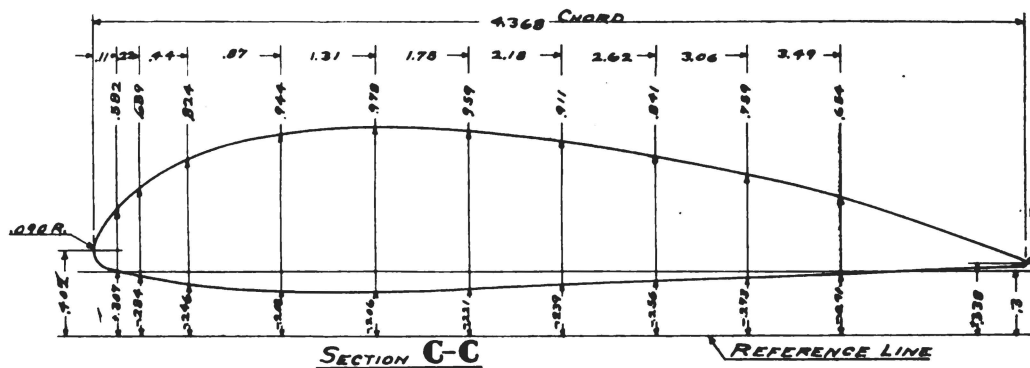
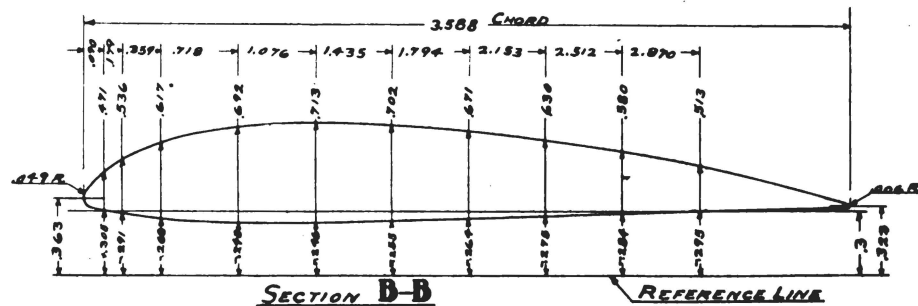
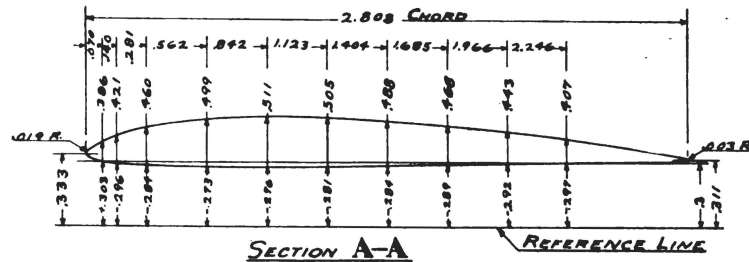


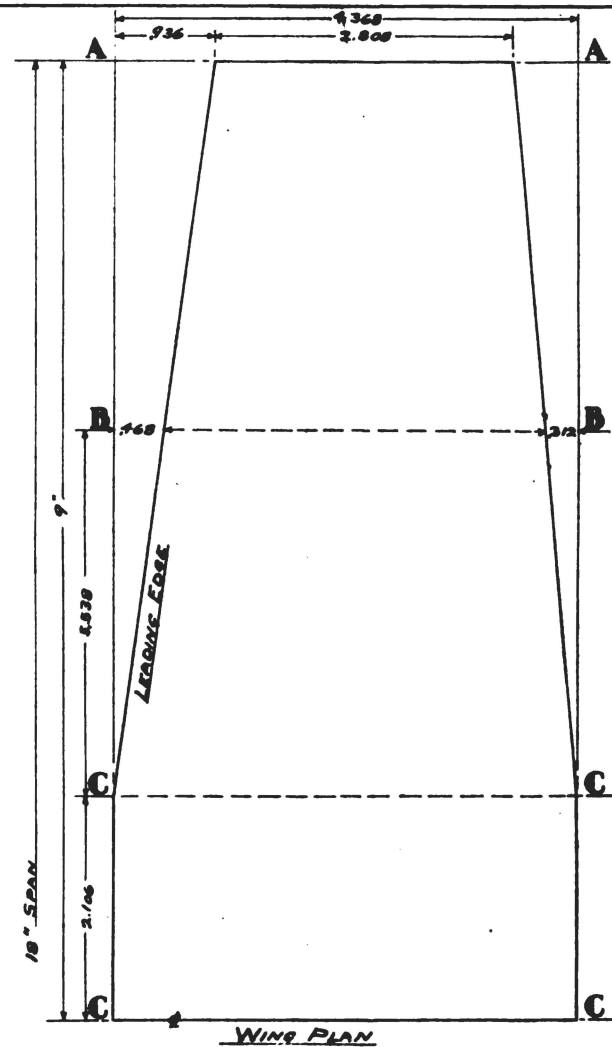
FIG. 2.

EXPERIMENTAL WING - USA-27C - LONG DISTANCE BOMBARDMENT - TYPE XIII



SECTION AT WING TIP WASHED OUT $1\frac{1}{2}^\circ$ WITH RESPECT TO SECTION C-C.

LINE JOINING 3 OF CHORD ON UPPER SURFACE AT ALL SECTIONS IS HORIZONTAL.



M-1785

FIG. 3.